

Having described the invention, the following is claimed:

1. Apparatus for helping to protect an occupant of a vehicle that has a side structure and a roof, said apparatus comprising:

an inflatable vehicle occupant protection device that is inflatable away from the vehicle roof into a position between the side structure of the vehicle and a vehicle occupant, said inflatable vehicle occupant protection device defining an inflatable volume and having a length extending along the side structure of the vehicle, said inflatable volume including a forward portion for location forwardly in the vehicle and a rearward portion for location rearwardly in the vehicle;

an inflation fluid source that provides inflation fluid for inflating said inflatable vehicle occupant protection device, said inflation fluid consisting essentially of helium; and

a fill tube having a portion located in said inflatable vehicle occupant protection device extending into said forward portion and said rearward portion of said inflatable volume, said fill tube being in fluid

communication with said inflation fluid source, said inflation fluid source, when actuated, providing said inflation fluid to said fill tube, said fill tube including outlet apertures positioned along said portion of said fill tube for directing said inflation fluid into said inflatable volume to inflate said inflatable vehicle occupant protection device initially to a first desired pressure and maintain said inflatable vehicle occupant protection device inflated above a second desired pressure for a predetermined period of time, said predetermined period of time being at least 5-7 seconds;

said inflation fluid being directed through said outlet apertures into said forward portion and said rearward portion of said inflatable volume to inflate said forward and rearward portions, said inflation fluid directed into said forward portion and said inflation fluid directed into said rearward portion having generally the same temperature and generally the same pressure during initial inflation of said inflatable vehicle occupant protection device, said inflation fluid in said inflatable vehicle occupant protection device having a temperature about equal to an ambient temperature in which said

inflatable vehicle occupant protection device is inflated for at least 95% of said predetermined period of time.

2. Apparatus as defined in claim 1, wherein said fill tube has a predetermined number of said outlet apertures spaced a predetermined distance apart from each other along said portion of said fill tube, said predetermined number of outlet apertures and said predetermined distance being selected to provide said inflation fluid in said forward and rearward portions at generally the same pressure and temperature.

3. Apparatus as defined in claim 2, wherein said outlet apertures are arranged in groups, each of said groups including a plurality of said outlet apertures, said groups being spaced apart from each other along said portion of said fill tube.

4. Apparatus as defined in claim 3, wherein said inflatable volume is defined by a perimeter of said inflatable vehicle occupant protection device, said perimeter being at least partially defined by an upper edge and an opposite lower edge of said inflatable

vehicle occupant protection device and front and rear edges spaced apart horizontally along said upper and lower edges, said upper edge extending along the side structure of the vehicle adjacent the roof of the vehicle.

5. Apparatus as defined in claim 4, wherein said fill tube has a first end connected to said inflation fluid source and an opposite second end located in said inflatable vehicle occupant protection device, said first end being positioned outside said inflatable vehicle occupant protection device near said rear edge of said inflatable vehicle occupant protection device.

6. Apparatus as defined in claim 5, wherein said outlet apertures are arranged in four groups spaced apart along said fill tube.

7. Apparatus as defined in claim 6, wherein each of said outlet apertures has a center and a diameter of about 7.0-9.0 millimeters, said outlet apertures in each of said four groups being arranged along a line and spaced along said line, said centers of adjacent

apertures in each said group being spaced about 12 millimeters apart.

8. Apparatus as defined in claim 6, wherein a first group of outlet apertures includes 3 of said outlet apertures.

9. Apparatus as defined in claim 8, wherein said first group of outlet apertures is spaced about 490 millimeters from said first end of said fill tube.

10. Apparatus as defined in claim 8, wherein a second group of outlet apertures includes 5 of said outlet apertures.

11. Apparatus as defined in claim 10, wherein said second group of outlet apertures is spaced about 144 millimeters from said first group of outlet apertures.

12. Apparatus as defined in claim 10, wherein a third group of outlet apertures includes 8 of said outlet apertures.

13. Apparatus as defined in claim 12, wherein said third group of outlet apertures is spaced about 485 millimeters from said second group of outlet apertures.

14. Apparatus as defined in claim 12, wherein a fourth group of outlet apertures includes 8 of said outlet apertures.

15. Apparatus as defined in claim 14, wherein said fourth group of outlet apertures is spaced about 85 millimeters from said third group of outlet apertures.

16. Apparatus as defined in claim 2, wherein said fill tube has an outside diameter of about 15.875 millimeters and a wall thickness of about 0.71 millimeters.

17. Apparatus as defined in claim 1, wherein said inflation fluid is directed through each of said outlet apertures at a supersonic velocity.

18. Apparatus as defined in claim 17, wherein the supersonic velocity of said inflation fluid creates a shock wave that causes the temperature of said inflation fluid to increase.

19. Apparatus as defined in claim 1, wherein said inflatable vehicle occupant protection device includes a non-inflatable portion located between said forward portion and said rearward portion.

20. Apparatus as defined in claim 1, wherein said inflatable vehicle occupant protection device is an inflatable curtain having a stored position extending along the side structure adjacent a roof of the vehicle, said inflatable curtain being inflated away from the vehicle roof into said position between the side structure of the vehicle and a vehicle occupant.

21. Apparatus as defined in claim 20, wherein said inflatable curtain when inflated extends along the side structure of the vehicle between an A pillar and a C pillar of the vehicle.

22. Apparatus as defined in claim 20, wherein said inflatable curtain, when inflated, overlies at least a portion of an A pillar, a B pillar and a C pillar of the vehicle.

23. Apparatus as defined in claim 1, further comprising a sensor for sensing a vehicle condition for which deployment of said inflatable vehicle occupant protection device is desired, said sensor actuating said inflation fluid source to provide inflation fluid to inflate said inflatable vehicle occupant protection device.

24. Apparatus as defined in claim 1, wherein said inflation fluid source comprises an inflator which is actuatable to inflate said inflatable vehicle occupant protection device.

25. Apparatus as defined in claim 24, wherein said inflator is a stored gas inflator, said inflation fluid being compressed and stored at about 6250 psig.



26. Apparatus as defined in claim 1, wherein said fill tube directs said inflation fluid into said inflatable vehicle occupant protection device at generally the same temperature and pressure throughout said predetermined period of time.

27. Apparatus as defined in claim 26, wherein said inflation fluid inflates said inflatable vehicle occupant protection device evenly along the length of said inflatable vehicle occupant protection device.

28. Apparatus as defined in claim 27, wherein said outlet apertures are positioned and spaced to cause said inflatable vehicle occupant protection device to inflate evenly along the length of said inflatable vehicle occupant protection device.

29. Apparatus as defined in claim 1, wherein said generally the same temperature is just above said ambient temperature in which said inflatable vehicle occupant protection device is inflated.

30. Apparatus as defined in claim 1, wherein said fill tube contains a volume of air prior to actuation of said inflation fluid source, said fill tube being constructed such that said volume of air undergoes adiabatic compressive heating in said fill tube upon actuation of said inflation fluid source, said inflation fluid gaining heat from said volume of air.

31. Apparatus as defined in claim 30, wherein said inflation fluid gains heat thermodynamically from said fill tube.

32. Apparatus as defined in claim 1, wherein said generally the same temperature is about equal to said ambient temperature for at least 98% of said predetermined period of time.

33. Apparatus as defined in claim 1, wherein said first predetermined pressure is about 149-163 kilopascals absolute.

34. Apparatus as defined in claim 1, wherein said second predetermined pressure is about 125 kilopascals absolute.

35. Apparatus for helping to protect an occupant of a vehicle that has a side structure and a roof, said apparatus comprising:

an inflatable vehicle occupant protection device that is inflatable away from the vehicle roof into a position between the side structure of the vehicle and a vehicle occupant, said inflatable vehicle occupant protection device defining an inflatable volume and having a length extending along the side structure of the vehicle;

an inflation fluid source that provides inflation fluid for inflating said inflatable vehicle occupant protection device, said inflation fluid consisting essentially of helium; and

a fill tube having a portion located in said inflatable vehicle occupant protection device extending into said inflatable volume, said fill tube being in fluid communication with said inflation fluid source, said inflation fluid source, when actuated, providing said inflation fluid to said fill tube, said fill tube including outlet apertures positioned along said portion of said fill tube for directing said inflation fluid into said inflatable volume to inflate said

inflatable vehicle occupant protection device initially to a first desired pressure and maintain said inflatable vehicle occupant protection device inflated above a second desired pressure for a predetermined period of time, said predetermined period of time being at least 5-7 seconds;

said inflation fluid being directed through said outlet apertures into said inflatable volume to inflate said inflatable volume, said inflation fluid directed into said inflatable volume having a temperature that is generally the same and a pressure that is generally the same throughout the length of said inflatable vehicle occupant protection device during initial inflation of said inflatable vehicle occupant protection device, said inflation fluid in said inflatable vehicle occupant protection device having a temperature about equal to an ambient temperature in which said inflatable vehicle occupant protection device is inflated for at least 95% of said predetermined period of time.

36. Apparatus as defined in claim 35, wherein said fill tube has a predetermined number of said outlet apertures spaced a predetermined distance apart

from each other along said portion of said fill tube, said predetermined number of outlet apertures and said predetermined distance being selected to provide said inflation fluid in said forward and rearward portions at generally the same pressure and temperature.

37. Apparatus as defined in claim 35, wherein said fill tube directs said inflation fluid into said inflatable vehicle occupant protection device at generally the same temperature and pressure throughout said predetermined period of time.

38. Apparatus as defined in claim 37, wherein said inflation fluid inflates said inflatable vehicle occupant protection device evenly along the length of said inflatable vehicle occupant protection device.

39. Apparatus as defined in claim 38, wherein said outlet apertures are positioned and spaced to cause said inflatable vehicle occupant protection device to inflate evenly along the length of said inflatable vehicle occupant protection device.

40. Apparatus as defined in claim 35, wherein said generally the same temperature is just above said ambient temperature in which said inflatable vehicle occupant protection device is inflated.

41. Apparatus as defined in claim 35, wherein said generally the same temperature is about equal to said ambient temperature for at least 98% of said predetermined period of time.

42. Apparatus for helping to protect an occupant of a vehicle that has a side structure and a roof, said apparatus comprising:

an inflatable vehicle occupant protection device that is inflatable away from the vehicle roof into a position between the side structure of the vehicle and a vehicle occupant, said inflatable vehicle occupant protection device defining an inflatable volume and having a length extending along the side structure of the vehicle, said inflatable volume including a forward portion for location forwardly in the vehicle and a rearward portion for location rearwardly in the vehicle; and

an inflation fluid source that provides inflation fluid for inflating said inflatable vehicle occupant protection device, said inflation fluid source, when actuated, providing said inflation fluid to inflate said inflatable vehicle occupant protection device initially to a first desired pressure and maintain said inflatable vehicle occupant protection device inflated above a second desired pressure for a predetermined period of time, said predetermined period of time being at least 5-7 seconds, said inflation fluid source comprising a stored gas inflator containing said inflation fluid under pressure, said inflation fluid consisting essentially of helium;

said inflation fluid being directed into said forward portion and said rearward portion of said inflatable volume to inflate said forward and rearward portions, said inflation fluid directed into said forward portion and said inflation fluid directed into said rearward portion having a temperature that is generally the same during initial inflation of said inflatable vehicle occupant protection device, said inflation fluid directed into said inflatable vehicle occupant protection device having a temperature about equal to an ambient temperature in which said

inflatable vehicle occupant protection device is inflated for at least 95% of said predetermined period of time.

43. Apparatus as defined in claim 42, wherein said generally the same temperature is about equal to said ambient temperature for at least 98% of said predetermined period of time.

44. Apparatus as defined in claim 42, wherein said outlet apertures are positioned and spaced to cause said inflatable vehicle occupant protection device to inflate evenly along the length of said inflatable vehicle occupant protection device.

45. Apparatus as defined in claim 42, wherein said generally the same temperature is just above said ambient temperature.

46. A method for helping to protect an occupant of a vehicle that has a side structure and a roof, said method comprising the steps of:

providing an inflatable vehicle occupant protection device that is inflatable away from the



vehicle roof into a position between the side structure of the vehicle and a vehicle occupant, said inflatable vehicle occupant protection device defining an inflatable volume and having a length extending along the side structure of the vehicle, said inflatable volume including a forward portion for location forwardly in the vehicle and a rearward portion for location rearwardly in the vehicle;

providing an inflation fluid source that provides inflation fluid for inflating said inflatable vehicle occupant protection device, said inflation fluid source, when actuated, providing said inflation fluid to inflate said inflatable vehicle occupant protection device initially to a first desired pressure and maintain said inflatable vehicle occupant protection device inflated above a second desired pressure for a predetermined period of time, said predetermined period of time being at least 5-7 seconds, said inflation fluid consisting essentially of helium; and

directing said inflation fluid into said forward portion and said rearward portion of said inflatable volume, said inflation fluid directed into said forward portion and said inflation fluid directed

into said rearward portion having a temperature that is generally the same and a pressure that is generally the same during initial inflation of said inflatable vehicle occupant protection device to cause said inflatable vehicle occupant protection device to inflate evenly throughout the length of said inflatable vehicle occupant protection device, said inflation fluid directed into said inflatable vehicle occupant protection device having a temperature about equal to an ambient temperature in which said inflatable vehicle occupant protection device is inflated for at least 95% of said predetermined period.

47. The method of claim 46, wherein said step of directing said inflation fluid comprises providing a fill tube having a portion located in said inflatable vehicle occupant protection device extending into said inflatable volume, said fill tube being in fluid communication with said inflation fluid source, said inflation fluid source, when actuated, providing said inflation fluid to said fill tube, said fill tube including outlet apertures positioned along said portion of said fill tube for directing said inflation fluid into said inflatable volume to inflate said

inflatable vehicle occupant protection device, said inflation fluid being directed through said outlet apertures into said forward and rearward portions of said inflatable volume, said inflation fluid directed into said forward portion and said inflation fluid directed into said rearward portion having generally the same temperature and pressure along the length of said inflatable vehicle occupant protection device throughout said predetermined period of time to inflate evenly along the length of said inflatable vehicle occupant protection device.

48. The method of claim 47, further comprising the steps of providing said fill tube having a predetermined cross-sectional flow area and a predetermined number of said outlet apertures spaced a predetermined distance apart from each other along said portion of said fill tube, said predetermined cross-sectional flow area, said predetermined number of outlet apertures, and said predetermined distance being selected to provide said inflation fluid in said forward and rearward portions at generally the same pressure and temperature.

49. The method of claim 48, further comprising the steps of arranging said outlet apertures in groups that include a plurality of said outlet apertures and spacing said groups apart from each other along said portion of said fill tube.

50. The method of claim 49, further comprising the steps of creating a computer-generated model to select said predetermined number of said outlet apertures and said predetermined spacing of said outlet apertures.

51. The method of claim 50, wherein said step of creating a computer-generated model comprises creating a two-dimensional computational fluid dynamics model.

52. Apparatus for helping to protect an occupant of a vehicle that has a side structure and a roof, said apparatus comprising:

an inflatable vehicle occupant protection device that is inflatable away from the vehicle roof into a position between the side structure of the vehicle and a vehicle occupant, said inflatable vehicle occupant protection device defining an inflatable

volume and having a length extending along the side structure of the vehicle;

an inflation fluid source for providing inflation fluid to inflate said inflatable vehicle occupant protection device, said inflation fluid consisting essentially of helium; and

a fill tube having a portion located in said inflatable vehicle occupant protection device, said fill tube being in fluid communication with said inflation fluid source, said inflation fluid source, when actuated, providing said inflation fluid to said fill tube, said fill tube directing said inflation fluid into said inflatable volume to inflate said inflatable vehicle occupant protection device initially to a first desired pressure and maintain said inflatable vehicle occupant protection device inflated above a second desired pressure for a predetermined period of time, said predetermined period of time being at least 5-7 seconds, said fill tube being adapted to deliver said inflation fluid into said inflatable volume such that said inflation fluid directed into said inflatable vehicle occupant protection device has a temperature about just above an ambient temperature

in which said inflatable vehicle occupant protection device is inflated.

53. Apparatus as defined in claim 52, wherein said fill tube is adapted to deliver said inflation fluid in said inflatable volume at said temperature about just above said ambient temperature generally equally throughout the length of said inflatable vehicle occupant protection device during initial inflation of said inflatable vehicle occupant protection device.

54. Apparatus as defined in claim 53, wherein said fill tube is adapted to deliver said inflation fluid into said inflatable volume at generally the same pressure along the length of said inflatable vehicle occupant protection device during initial inflation of said inflatable vehicle occupant protection device to cause said inflatable vehicle occupant protection device to inflate evenly along the length of said inflatable vehicle occupant protection device.